J. Chem. Sci. Vol. 124, No. 5, September 2012, pp. 1007–1012.

A facile and expedient one-pot three-component reaction leading to multifunctionalized stabilized phosphorus ylides

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MS received 14 August 2011; revised 17 March 2012; accepted 20 April 2012

Abstract. A three-component reaction between triphenylphosphine, a dialkyl acetylenedicarboxylate and phthalazin-1(2H)-ones that affords novel organic phosphorane derivatives in good to excellent yields is reported. FTIR, ^{1}H, ^{13}C and ^{31}P NMR and elemental analyses have been utilized to characterize the synthesized compounds.

Keywords. Phosphoranes; acetylenic esters; heterocyclic compounds; phthalazin-1(2H)-one; three-component reaction.

1. Introduction

Phthalazin-1(2H)-one and their analogues represent an important class of nitrogen-containing heterocyclic compounds which exhibit useful biological activities. Particularly, in recent years, stilbene-related heterocyclic compounds comprising of benzalphthalide, phthalazinone, imidazoindole and pyrimidoisoindole derivatives have been tested for their anti-HIV activity.[1] Some phthalazin-1-ones and their derivatives have shown pharmacological utility as vasorelaxant,[2] polymerase inhibitors,[3] anxiolytics[4] and antiprotozoal potency.[5,6] recently, one-pot multicomponent reactions have emerged as a forceful tool in synthetic organic chemistry due to their significant advantages.[7,8] A practical and expedient construction of highly functionalized and diversified molecules from simple starting materials is highly desirable and is considered as a great challenge.

In recent years, as part of our studies on the development of useful and beneficial methods for the preparation of organic compounds, we have been interested in the synthesis of organophosphorus compounds;[9] that is, those bearing a carbon atom bound directly to a phosphorus atom. This interest is due to usefullness of such compounds in a variety of biological, industrial and synthetic applications.[10–13]

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2. Experimental

2.1 *General procedures*

The ^{1}H and ^{13}C NMR spectra were acquired from a BRUKER DRX-500 AVANCE NMR spectrometer (using $SiMe_4$ as the internal standard). ^{31}P NMR spectra was recorded on a Bruker Avance DRX instrument at 162.0 MHz. Infrared absorption spectra were obtained from 4000 to 400 cm^{-1} in KBr pellet using a MATTSON 1000 FT-IR spectrometer. Elemental analyses were performed using Heracus CHN-O-Rapid analyzer. Melting points were determined on an Electrothermal 9200 apparatus and are uncorrected.

All chemicals were purchased from Merck or Fluka and Sigma-Aldrich Chemical Companies. All common reagents and solvents were used as obtained from commercial suppliers without further purification. Benzalphthalide was prepared from phthalic anhydride and phenylacetic acid in the presence of sodium acetate following a protocol mentioned in the literature.[1–6,21] Phthalazin-1(2H)-one was prepared by us through condensation of benzalphthalides with hydrazines under reflux according to a method used by other reserchers.[1–6,22]

Dimethyl acetylenedicarboxylate (0.12 mL, 1 mmol) was added drop-wise to a magnetically stirred solution of triphenylphosphine (0.26 g, 1 mmol) and Phthalazin-1(2H)-one (0.24 g, 1 mmol) in 20 mL of acetone as a solvent. After the addition was complete (approximately 5 min), the mixture was stirred for an additional 3 h at ambient temperature before being filtered.

The collected solids were washed thoroughly with acetone yielding a white powder.

2.1a *Dimethyl 2-[4-benzyl-1-oxo-2(1H)phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5a**): (White powder, 0.60 g, m.p 116–118°C, yield 93%); IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1612 (C=O). Anal. Calcd. For $C_{39}H_{33}N_2O_5P$ (640.66): C, 73.11; H, 5.19; N, 4.37%. Found: C, 73.23; H, 5.09; N, 4.28%. Isomer, (E) (55%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.55 and 3.61 (6H, 2s, 2 OCH_3), 4.29 (2H, s, CH_2), 6.34 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH), 7.20–8.34 (48H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 39.05 (CH_2), 40.86 (d, $^1J_{PC}$ = 139.6 Hz, P=C)*, 50.38 and 52.16 (2 OCH_3), 61.28 (d, $^2J_{PC}$ = 13.8 Hz, P=C–CH), 124.95 (CH)*, 127.34 (d, $^1J_{PC}$ = 83.0 Hz, C^{ipso}), 126.52 (CH), 127.33 (CH)*, 128.19 (C), 128.32 (CH), 128.50 (CH)*, 128.64 (d, $^3J_{PC}$ = 11.3 Hz, C^{meta})*, 129.46 (CH)*, 130.55 (CH), 131.90 (C^{para})*, 132.57 (C), 133.90 (d, $^2J_{PC}$ = 6.3 Hz, C^{ortho}), 138.49 (C), 143.31 (C), 158.93 (C=O), 171.49 (d, $^2J_{PC}$ = 12.6 Hz, C=O), 171.49 (d, $^3J_{PC}$ = 7.5 Hz, C=O)* ppm.^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 22.80 ppm. Isomer, (Z) (45%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.15 and 3.60 (6H, 2s, 2 OCH_3), 4.32 (2H, s, CH_2), 6.26 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 39.11 (CH_2), 49.10 and 52.27 (2 OCH_3), 61.08 (d, $^2J_{PC}$ = 15.1 Hz, P=C–CH), 126.60 (d, $^1J_{PC}$ = 84.3 Hz, C^{ipso}), 126.43 (CH), 128.26 (C), 128.43 (CH), 130.47 (CH), 132.43 (C), 133.82 (d, $^2J_{PC}$ = 6.3 Hz, C^{ortho}), 138.66 (C), 143.26 (C), 158.99 (C=O), 170.06 (d, $^2J_{PC}$ = 12.6 Hz, C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.00 ppm.

2.1b *Diethyl 2-[4-benzyl-1-oxo-2(1H)phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5b**): (White powder, 0.61 g, m.p 200–202°C, yield 91%) IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1610 (C=O). Anal. Calcd. For $C_{41}H_{37}N_2O_5P$ (668.72): C, 73.64; H, 5.58; N, 4.19%. Found: C, 73.70; H, 5.47; N, 4.26%. Isomer, (E) (52%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.17 (3H, t, $^3J_{HH}$ = 5.0 Hz, CH_3), 1.28 (3H, t, $^3J_{HH}$ = 5.0 Hz, CH_3), 3.70–4.17 (8H, m, 4 OCH_2)*, 4.326 (2H, s, CH_2), 4.36 (2H, d, $^2J_{HH}$ = 15.0 Hz, CH_2)*, 6.02 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH), 7.21–8.35 (48H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 13.96 and 14.05 (2 CH_3), 39.06 (CH_2), 40.76 (d, $^1J_{PC}$ = 139.6 Hz, P=C), 57.64 and 60.89 (2 OCH_2), 61.16 (d, $^2J_{PC}$ = 15.1 Hz, P=C–CH), 124.85 (CH)*, 126.48 (CH), 126.92 (d, $^1J_{PC}$ = 93.1 Hz, C^{ipso}), 127.34 (CH), 128.25 (C)*, 128.42 (CH)*, 128.59 (d, $^3J_{PC}$ = 11.3 Hz, C^{meta}), 129.45 (CH), 130.35 (CH)*, 131.76 (C^{para})*, 132.29 (CH), 132.40 (C), 133.81 (d, $^2J_{PC}$ = 10.1 Hz, C^{ortho}), 138.62 (C), 143.04 (C), 158.86 (C=O), 170.93 (d, $^2J_{PC}$ = 11.3 Hz, C=O), 171.56 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.00 ppm. Isomer, (Z) (48%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.48 (3H, t, $^3J_{HH}$ = 5.0 Hz, CH_3), 1.22 (3H, t, $^3J_{HH}$ = 5.0 Hz, CH_3), 6.39 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 14.12 and 14.96 (2 CH_3), 39.21 (CH_2), 39.28 (d, $^1J_{PC}$ = 132.0 Hz, P=C), 58.37 and 60.90 (2 OCH_2), 61.18 (d, $^2J_{PC}$ = 13.8 Hz, P=C–CH), 126.37 (CH), 127.66 (d, $^1J_{PC}$ = 91.8 Hz, C^{ipso}), 127.40 (CH), 128.40 (d, $^3J_{PC}$ = 11.3 Hz, C^{meta}), 129.49 (CH), 133.97 (d, $^2J_{PC}$ = 10.1 Hz, C^{ortho}), 138.78 (C), 142.96 (C), 158.82 (C=O), 170.87 (d, $^2J_{PC}$ = 11.3 Hz, C=O), 171.42 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.06 ppm.

2.1c *Dimethyl 2-[4-(4-methoxybenzyl-1-oxo-2(1H) phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5c**): (White powder, 0.55 g, m.p 124–126°C, yield 82%); IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1625 (C=O). Anal. Calcd. For $C_{40}H_{35}N_2O_5P$ (670.69): C, 71.63; H, 5.26; N, 4.18%. Found: C, 71.69; H, 5.16; N, 4.08%. Isomer, (E) (58%) (^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.56 and 3.59 (6H, 2s, 2 OCH_3), 3.79 (3H, s, OCH_3), 4.25 (2H, s, CH_2), 6.29 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH), 6.80–8.35 (46H, m, arom)* ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.26 (CH_2), 40.84 (d, $^1J_{PC}$ = 139.4 Hz, P=C)*, 50.36 and 52.13 (2 OCH_3), 55.27 (2 OCH_3)*, 61.24 (d, $^2J_{PC}$ = 14.6 Hz, P=C–CH), 114.12 (CH), 124.95 (CH)*, 126.73 (d, $^1J_{PC}$ = 92.2 Hz, C^{ipso}), 127.36 (CH)*, 128.27 (C), 128.63 (d, $^3J_{PC}$ = 12.1 Hz, C^{meta}), 129.28 (CH)*, 129.42 (CH), 130.36 (C), 130.54 (C), 131.34 (d, $^4J_{PC}$ = 2.5 Hz, C^{para})*, 132.46 (CH), 133.90 (d, $^2J_{PC}$ = 9.8 Hz, C^{ortho}), 143.54 (C), 158.28 (C), 158.96 (C=O), 171.48 (d, $^2J_{PC}$ = 11.2 Hz, C=O), 171.61 (d, $^3J_{PC}$ = 6.1 Hz, C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 22.70 ppm. Isomer, (Z) (42%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.14 and 3.59 (6H, 2s, 2 OCH_3), 3.78 (3H, s, OCH_3), 4.21 (2H, s, CH_2), 6.22 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH) ppm.^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.30 (CH_2), 49.04 and 52.25 (2 OCH_3), 62.07 (d, $^2J_{PC}$ = 14.4 Hz, P=C–CH), 114.22 (CH), 127.41 (d, $^1J_{PC}$ = 91.9 Hz, C^{ipso}), 128.33 (C), 128.53 (d, $^3J_{PC}$ = 11.9 Hz, C^{meta}), 129.46 (CH), 130.44 (C), 130.71 (C), 132.32 (CH), 133.86 (d, $^2J_{PC}$ = 9.6 Hz, C^{ortho}), 143.45(C), 158.22 (C), 158.90 (C=O), 169.97 (d, $^2J_{PC}$ = 11.2 Hz, C=O), 171.75 (d, $^3J_{PC}$ = 6.1 Hz, C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.09 ppm.

2.1d *Diethyl 2-[4-methoxybenzyl-1-oxo-2(1H) phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5d**): (White powder, 0.56 g, m.p 100–103°C, yield 80%) IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1625 (C=O). Anal. Calcd. For $C_{42}H_{39}N_2O_6P$ (698.74): C, 72.19; H, 5.63; N, 4.01%. Found: C, 72.22; H, 5.56; N, 3.95%. Isomer, (Z) (60%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.47 (3H, t, $^3J_{HH}$ = 7.1 Hz, CH_3), 1.17 (3H, t, $^3J_{HH}$ = 7.1 Hz, CH_3), 3.78 (3H, s, OCH_3), 3.69–4.08 (8H, m, 4 OCH_2)*, 4.27 (2H, s, CH_2), 6.01 (1H, d, $^3J_{PH}$ = 23.5 Hz, P=C–CH), 6.80–8.46 (46H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 13.96 and 14.96 (2 CH_3), 38.22 (CH_2), 40.81 (d, $^1J_{PC}$ = 139.6 Hz, P=C), 55.26 and 57.66 (2 OCH_2), 60.89 (2 OCH_3)*, 61.13 (d, $^2J_{PC}$ = 15.6 Hz, P=C–CH), 114.08 (CH), 124.86 (CH), 126.94 (d, $^1J_{PC}$ = 92.8 Hz, C^{ipso}), 127.33 (CH), 128.41 (C), 128.42 (d, $^3J_{PC}$ = 12.2 Hz, C^{meta}), 129.32 (CH), 130.30 (CH), 130.65 (C), 131.79 (C^{para})*, 132.36 (CH), 133.82 (d, $^2J_{PC}$ = 9.8 Hz, C^{ortho}), 143.36 (C), 158.21 (C), 158.82 (C=O), 170.89 (d, $^2J_{PC}$ = 12.2 Hz, C=O), 171.45 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.12 ppm. Isomer, (E) (40%)^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.91 (3H, t, $^3J_{HH}$ = 7.1 Hz, CH_3), 1.22 (3H, t, $^3J_{HH}$ = 7.1 Hz, CH_3), 3.79 (3H, s, OCH_3), 4.30 (2H, s, CH_2), 6.38 (1H, d, $^3J_{PH}$ = 23.5 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 14.06 and 14.13 (2 CH_3), 38.38 (CH_2), 39.30 (d, $^1J_{PC}$ = 135.5 Hz, P=C), 58.38 and 60.39 (2 OCH_2), 62.18 (d, $^2J_{PC}$ = 14.4 Hz, P=C–CH), 114.09 (CH), 124.90 (CH), 127.67 (d, $^1J_{PC}$ = 92.1 Hz, C^{ipso}), 127.39 (CH), 128.29 (C), 128.61 (d, $^3J_{PC}$ = 12.3 Hz, C^{meta}), 129.41 (CH), 129.47 (CH), 130.77 (C), 132.25 (CH), 133.98 (d, $^2J_{PC}$ = 9.8 Hz, C^{ortho}), 143.28 (C), 158.28 (C), 158.88 (C=O), 169.52 (d, $^2J_{PC}$ = 13.6 Hz, C=O), 171.59 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.20 ppm.

2.1e *Dimethyl 2-[4-(4-chlorobenzyl-1-oxo-2(1H) phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5e**): (Pale yellow powder, 0.66 g, m.p 138–140°C, yield 98%); IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1625 (C=O). Anal. Calcd. For $C_{39}H_{32}ClN_2O_5P$ (675.11): C, 69.38; H, 4.78; N, 4.15%. Found: C, 69.41; H, 4.71; N, 4.08%. Isomer, (E) (60%) ^{1}HNMR (500 MHz, $CDCl_3$): δ = 3.58 and 3.60 (6H, 2s, 2 OCH_3), 4.28 (2H, s, CH_2), 6.15 (1H, d, $^3J_{PH}$ = 22.0 Hz, P=C–CH), 7.16–8.35 (46H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.40 (CH_2), 40.81 (d, $^1J_{PC}$ = 139.3 Hz, P=C), 49.04 and 52.17 (2 OCH_3), 61.31 (d, $^2J_{PC}$ = 14.7 Hz, P=C–CH), 124.63 (CH), 126.66 (d, $^1J_{PC}$ = 92.1 Hz, C^{ipso}), 127.49 (CH)*, 128.25 (C), 128.56 (d, $^3J_{PC}$ = 12.0 Hz, C^{meta}), 129.74 (CH), 129.268 (CH)*, 129.94 (CH), 130.64 (C), 131.93 (d, $^4J_{PC}$ = 2.3 Hz, C^{para})*, 132.37 (C), 132.60 (CH), 133.85 (d, $^2J_{PC}$ = 9.3 Hz, C^{ortho}), 136.59 (C), 142.78 (C), 158.87 (C=O), 171.44 (d, $^2J_{PC}$ = 11.5 Hz, C=O), 171.58 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 22.79 ppm. Isomer, (Z) (40%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.14 and 3.59 (6H, 2s, 2 OCH_3), 4.25 (2H, s, CH_2), 6.19 (1H, d, $^3J_{PH}$ = 22.0 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.91 (CH_2), 39.44 (d, $^1J_{PC}$ = 131.6 Hz, P=C), 50.34 and 52.31 (2 OCH_3), 62.07 (d, $^2J_{PC}$ = 14.8 Hz, P=C–CH), 124.58 (CH), 127.34 (d, $^1J_{PC}$ = 91.9 Hz, C^{ipso}), 128.29 (C), 128.75 (d, $^3J_{PC}$ = 12.3 Hz, C^{meta}), 129.26 (CH), 130.55 (C), 132.26 (C), 132.47 (CH), 133.77 (d, $^2J_{PC}$ = 9.0 Hz, C^{ortho}), 137.09 (C), 142.68 (C), 158.81 (C=O), 169.90 (d, $^2J_{PC}$ = 12.5 Hz, C=O), 171.73 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.10 ppm.

2.1f *Diethyl 2-[4-chlorobenzyl-1-oxo-2(1H)phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5f**): (Pale yellow powder, 0.62 g, m.p 118–120°C, yield 88%) IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1625 (C=O). Anal. Calcd. For $C_{41}H_{36}ClN_2O_5P$ (703.16): C, 70.03; H, 5.16; N, 3.98%. Found: C, 70.10; H, 5.10; N, 3.94%. Isomer, (E) (50%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.59 (3H, t, $^3J_{HH}$ = 6.8 Hz, CH_3), 1.23 (3H, t, $^3J_{HH}$ = 7.0 Hz, CH_3), 4.34 (2H, s, CH_2), 6.27 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH), 7.16–8.34 (46H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 13.95 and 14.95 (2 CH_3), 38.53 (CH_2), 40.78 (d, $^1J_{PC}$ = 136.0 Hz, P=C), 57.67 and 60.95 (2 OCH_2), 61.20 (d, $^2J_{PC}$ = 15.9 Hz, P=C–CH), 124.58 (CH), 126.87 (d, $^1J_{PC}$ = 92.5 Hz, C^{ipso}), 127.52 (CH), 128.44 (d, $^3J_{PC}$ = 12.2 Hz, C^{meta}), 128.73 (CH), 129.27 (C), 129.72 (CH)*, 129.93 (CH)*, 130.48(C), 131.86 (C^{para})*, 132.36 (C), 133.39 (CH), 133.78 (d, $^2J_{PC}$ = 9.7 Hz, C^{ortho}), 137.10 (C), 142.50 (C), 158.75 (C=O), 170.84 (d, $^2J_{PC}$ = 12.5 Hz, C=O), 170.91 (d, $^3J_{PC}$ = 10.6 Hz, C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.10 ppm. Isomer, (Z) (50%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.47 (3H, t, $^3J_{HH}$ = 7.0 Hz, CH_3), 1.29 (3H, t, $^3J_{HH}$ = 7.0 Hz, CH_3), 3.99–4.08 (8H, m, 4 OCH_2)*, 4.30 (2H, s, CH_2), 5.95 (1H, d, $^3J_{PH}$ = 20.0 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 14.10 and 14.14 (2 CH_3), 38.36 (CH_2), 39.17 (d, $^1J_{PC}$ = 136.7 Hz, P=C), 58.36 and 60.94 (2 OCH_2), 62.13 (d, $^2J_{PC}$ = 14.7 Hz, P=C–CH), 124.51 (CH), 127.61 (d, $^1J_{PC}$ = 92.4 Hz, C^{ipso}), 127.48 (CH), 128.63 (d, $^3J_{PC}$ = 12.3 Hz, C^{meta}), 128.78 (CH), 129.27 (C), 130.51 (C), 132.24 (C), 132.50 (CH), 133.89 (d, $^2J_{PC}$ = 9.7 Hz, C^{ortho}), 137.16 (C), 142.61 (C), 158.75 (C=O),

169.45 (d, $^{2}J_{PC}$ = 12.4 Hz, C=O), 171.40 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.16 ppm.

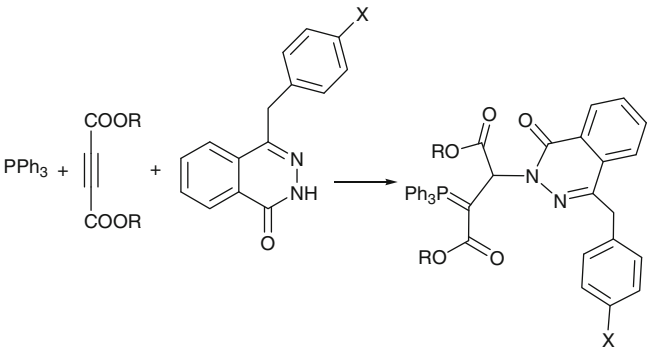
2.1g *Dimethyl 2-[4-(4-fluorobenzyl-1-oxo-2(1H) phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5g**): (White powder, 0.57 g, m.p 194–196°C, yield 86%); IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1600 (C=O). Anal. Calcd. For $C_{39}H_{32}FN_2O_5P$ (658.65): C, 71.12; H, 4.90; N, 4.25%. Found: C, 71.16; H, 4.84; N, 4.19%. Isomer, (E) (57%) ^{1}HNMR (500 MHz, $CDCl_3$): δ = 3.58 and 3.60 (6H, 2s, 2 OCH_3), 4.29 (2H, s, CH_2), 6.21 (1H, d, $^{3}J_{PH}$ = 20.9 Hz, P=C–CH), 6.93–8.32 (46H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.26 (CH_2), 40.36 (d, $^{1}J_{PC}$ = 90.5 Hz, P=C), 50.34 and 52.16 (2 OCH_3), 61.28 (d, $^{2}J_{PC}$ = 14.7 Hz, P=C–CH), 115.37 (d, $^{2}J_{CF}$ = 7.5 Hz, CH), 124.71 (CH), 126.68 (d, $^{1}J_{PC}$ = 92.0 Hz, C^{ipso}), 127.46 (CH)*, 128.28 (C), 128.66 (d, $^{3}J_{PC}$ = 12.1 Hz, C^{meta}), 129.30 (C)*, 129.76 (d, $^{3}J_{CF}$ = 7.8 Hz, CH), 131.92 (d, $^{4}J_{PC}$ = 2.0 Hz, C^{para})*, 132.56 (CH), 133.86 (d, $^{2}J_{PC}$ = 9.0 Hz, C^{ortho}), 134.14 (d, $^{4}J_{CF}$ = 2.8 Hz, C), 143.05 (C), 158.85 (d, $^{1}J_{CF}$ = 8.5 Hz, C)*, 160.66 (C=O), 171.40 (d, $^{2}J_{PC}$ = 12.5 Hz, C=O), 171.59 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.18 ppm. Isomer, (Z) (43%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.15 and 3.59 (6H, 2s, 2 OCH_3), 4.26 (2H, s, CH_2), 6.17 (1H, d, $^{3}J_{PH}$ = 21.2 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 38.29 (CH_2), 39.82 (d, $^{1}J_{PC}$ = 90.5 Hz, P=C), 49.03 and 52.29 (2 OCH_3), 62.06 (d, $^{2}J_{PC}$ = 14.6 Hz, P=C–CH), 115.54 (d, $^{2}J_{CF}$ = 7.5 Hz, CH), 124.70 (CH), 127.37 (d, $^{1}J_{PC}$ = 91.9 Hz, C^{ipso}), 128.33 (C), 128.56 (d, $^{3}J_{PC}$ = 11.9 Hz, C^{meta}), 129.98 (d, $^{3}J_{CF}$ = 7.8 Hz, CH), 132.43 (CH), 133.79 (d, $^{2}J_{PC}$ = 8.5 Hz, C^{ortho}), 134.25 (d, $^{4}J_{CF}$ = 2.8 Hz, C), 142.95 (C), 162.37 (C=O), 169.90 (d, $^{2}J_{PC}$ = 12.5 Hz, C=O), 171.72 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 22.88 ppm.

2.1h *Diethyl 2-[4-fluorobenzyl-1-oxo-2(1H) phthalazinyl]-3-(1,1,1-triphenyl-λ^5-phosphanylidene) succinate* (**5h**): (White powder, 0.60 g, m.p 204–206°C, yield 87%) IR (KBr) (ν_{max}, cm^{-1}): 1753, 1651 and 1600 (C=O). Anal. Calcd. For $C_{41}H_{36}FN_2O_5P$ (686.71): C, 71.71; H, 5.28; N, 4.08%. Found: C, 71.73; H, 5.18; N, 3.99%. Isomer, (E) (50%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.16 (3H, t, $^{3}J_{HH}$ = 7.0 Hz, CH_3), 1.29 (3H, t, $^{3}J_{HH}$ = 7.2 Hz, CH_3), 4.26 (2H, s, CH_2), 6.97 (1H, d, $^{3}J_{PH}$ = 20.8 Hz, P=C–CH), 6.94–8.34 (46H, m, arom)*ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 14.10 and 14.15 (2 CH_3), 38.23 (CH_2), 40.78 (d, $^{1}J_{PC}$ = 139.6 Hz, P=C), 57.65 and 60.93 (2 OCH_2), 61.18 (d, $^{2}J_{PC}$ = 15.8 Hz, P=C–CH), 115.35 (d, $^{2}J_{CF}$ = 5.8 Hz, CH), 124.60 (CH), 126.90 (d, $^{1}J_{PC}$ = 92.0 Hz, C^{ipso}), 127.44 (CH), 128.29 (C)*, 128.45 (d, $^{3}J_{PC}$ = 12.1 Hz, C^{meta}), 129.27 (C), 129.81 (d, $^{3}J_{CF}$ = 7.9 Hz, CH), 130.43 (CH), 131.86 (C^{para})*, 132.36 (CH), 133.79 (d, $^{2}J_{PC}$ = 9.9 Hz, C^{ortho}), 134.33 (d, $^{4}J_{CF}$ = 2.9 Hz, C), 142.78 (C), 158.86 (d, $^{1}J_{CF}$ = 8.5 Hz, C)*, 160.66 (C=O), 171.46 (d, $^{2}J_{PC}$ = 11.3 Hz, C=O), 171.59 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.08 ppm. Isomer, (Z) (50%) ^{1}H NMR (500 MHz, $CDCl_3$): δ = 0.47 (3H, t, $^{3}J_{HH}$ = 7.1 Hz, CH_3), 1.23 (3H, t, $^{3}J_{HH}$ = 7.1 Hz, CH_3), 3.69–4.32 (8H, m, 4 OCH_2)*, 4.31 (2H, s, CH_2), 5.94 (1H, d, $^{3}J_{PH}$ = 20.9 Hz, P=C–CH) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 13.97 and 14.95 (2 CH_3), 38.37 (CH_2), 39.35 (d, $^{1}J_{PC}$ = 133.3 Hz, P=C), 58.36 and 60.93 (2 OCH_2), 62.18 (d, $^{2}J_{PC}$ = 14.6 Hz, P=C–CH), 115.52 (d, $^{2}J_{CF}$ = 5.8 Hz, CH), 124.67 (CH), 127.48 (CH), 127.64 (d, $^{1}J_{PC}$ = 92.2 Hz, C^{ipso}), 128.63 (d, $^{3}J_{PC}$ = 12.2 Hz, C^{meta}), 129.31 (C), 129.98 (d, $^{3}J_{CF}$ = 7.7 Hz, CH), 130.42 (CH), 132.48 (CH), 133.92 (d, $^{2}J_{PC}$ = 9.8 Hz, C^{ortho}), 134.26 (d, $^{4}J_{CF}$ = 2.9 Hz, C), 142.88 (C), 162.57 (C=O), 169.91 (d, $^{2}J_{PC}$ = 12.5 Hz, C=O), 171.73 (C=O) ppm. ^{31}P NMR (162.0 MHz, $CDCl_3$): δ = 23.16 ppm.

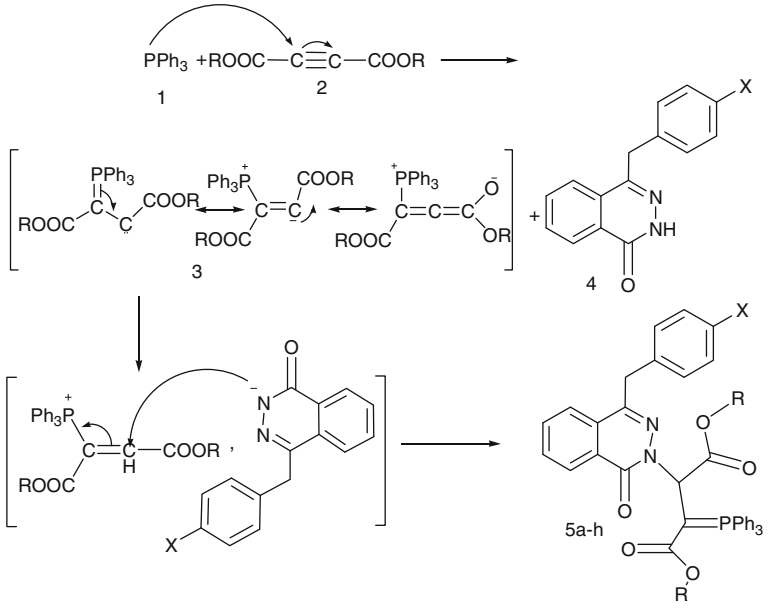
3. Results and discussion

In this paper, we describe the results of our studies on a three-component reaction between triphenylphosphine, dialkyl acetylenedicarboxylate, and substituted phthalazin-1(2H)-one that afford novel phosphorane derivatives (scheme 1). The reaction is created by simply mixing three common reactants.

On basis of the well-established chemistry of trivalent phosphorus as a good nucleophile[14,15] it is known that reaction of phosphorus(III) compounds with electron deficient alkynes[16] consists of an initial Michael-addition of triphenylphosphine **1** to dialkyl acetylenedicarboxylates **2**, to produce the carbene-ylide



Scheme 1. One-pot synthesis of substituted stabilized phosphorus ylides.



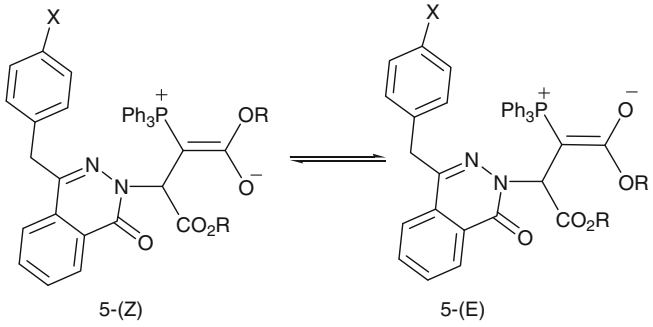
5	a	b	c	d	e	f	g	h
R	CH_3	CH_3CH_2	CH_3	CH_3CH_2	CH_3	CH_3CH_2	CH_3	CH_3CH_2
x	H	H	OCH_3	OCH_3	Cl	Cl	F	F

Scheme 2. The plausible mechanism for one-pot synthesis of multifunctionalized stabilized phosphorus ylides.

intermediate **3** which is sufficiently stabilized by resonance.[17–20] This is followed by protonation of the carbene-ylide intermediate by the NH acid **4**. The positively charged ion is then attacked by the nitrogen of the conjugated base of NH acid group to afford phthalazinone derivatives **5** that contain ylide as well as ester moieties (scheme 2).

Compounds **5a–h** are stable solids and their structures are revealed by elemental analyses and IR, ^{1}H, ^{13}C and ^{31}P NMR spectra. The ^{1}H, ^{13}C and ^{31}P NMR spectra of ylides **5a–h** are consistent with two isomers. These compounds exist in the solution as two geometrical isomers (Z) and (E); the principal cause of this phenomenon is due to the negative charge of ylide moiety which is conjugated with the adjacent carbonyl group. Rotation around the carbon–carbon double bond is slow on the NMR time scale for spontaneous interconversion process between (Z) and (E) geometrical isomers at room temperature (scheme 3).

The ^{1}H NMR spectrum of **5a** exhibited four sharp signals (δ = 3.15, 3.55, 3.60 and 3.61 ppm) readily recognized as arising from methoxy protons along with two signals for the methylene protons at δ = 4.29 and 4.32 (s, 2H, CH_2). The methine proton appeared at δ = 6.34 and 6.26 ppm, as a doublet ($^3J_{PH}$ = 20.0 Hz) that are consistent with the two isomers. The aromatic protons appear as a multiplet at δ = 7.20–8.34 ppm for two stereoisomers. ^{13}C and ^{31}P NMR spectrum of product **5a** is in agreement with the mixture of two geometrical isomers of Z and E. Although the presence of the ^{31}P nucleus has complicated both the ^{1}H and ^{13}C NMR spectra of **5a**, it helps in assignment of signals by long range spin–spin couplings with ^{1}H and ^{13}C nuclei. Partial assignments of these resonances are given in the experimental section. The ^{31}P NMR spectrum for compound **5a** indicated two signals at δ = 22.80 and 23.00 ppm due to the presence of two geometrical isomers. The ^{1}H, ^{13}C and ^{31}P NMR spectra for compound **5b** are similar to those of **5a**, except for ester groups, which exhibited characteristic resonances with appropriate chemical shifts. The ^{1}H, ^{13}C and ^{31}P NMR spectral data for compound **5c–h** are also consistent with the proposed structures (see the experimental section). The structural assignments made on the basis of ^{1}H and



Scheme 3. Geometrical isomers (Z) and (E).

^{13}C NMR spectra of compounds **5a–h** were supported by measurements of their IR spectra. The carbonyl region of the spectrum exhibited three distinct absorption bands for each compound (see experimental section). The special interest is the ester absorption at 1753–1659 cm^{-1} for these compounds. Conjugation with the negative charge appears to be a plausible factor for reduction in wave numbers of the carbonyl absorption bands.

4. Conclusions

In summary, the present study demonestrates that phosphorus ylides could be prepared by a simple, effective, one-pot three-component reaction of acetylenic esters, NH acids (phthalazin-1(2H)-one) and triphenylphosphine. High quality yields of the products and the relatively short reaction times are the main advantages of this method. The proposed method further carries the advantage that not only the reactions can be performed under neutral and mild conditions, but also the starting materials and reagents can be mixed without any activation or modification. In view of the widespread biological activities of phthalazinones derivatives, the fused phosphoranes with bioactive phthalazinones derivatives, as prepared in the present study could have useful applications in synthetic organic and bioorganic chemistry. The procedure described here may be employed as an admissible method for the preparation of phosphoranes with variable functionalities.

Acknowledgements

The authors gratefully acknowledge the financial support by the International Center for Science, High Technology and Environmental Sciences, Kerman, Iran. We also thank Dr. A Ahmadi for English language editing of the manuscript.

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